

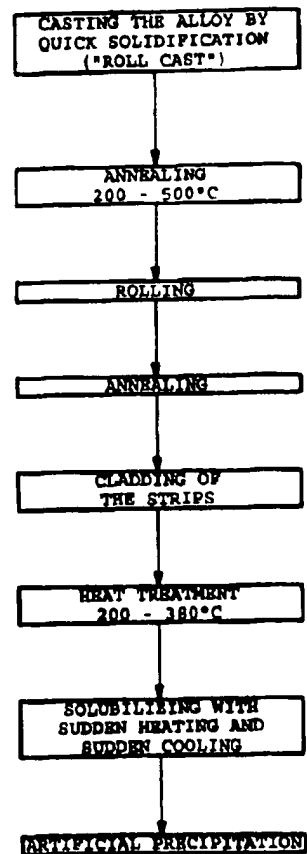
PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B32B 15/01, C22C 21/00, F16C 33/12		A1	(11) International Publication Number: WO 96/11800
			(43) International Publication Date: 25 April 1996 (25.04.96)
(21) International Application Number: PCT/BR95/00034		(81) Designated States: CA, MX, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).	
(22) International Filing Date: 28 July 1995 (28.07.95)			
(30) Priority Data: PI 9403710-8 13 October 1994 (13.10.94) BR		Published With international search report.	
(71) Applicant (for all designated States except US): METAL LEVE S/A. INDÚSTRIA E COMÉRCIO [BR/BR]; Rua Brasília Luz, 535, 04746-901-São Paulo, SP (BR).			
(72) Inventors; and			
(75) Inventors/Applicants (for US only): DE OLIVEIRA RAMOS, Joaquim, Jr. [BR/BR]; Apartamento 91, Avenida Leonardo da Vinci, 1301, 04313-001-São Paulo, SP (BR). DA CUNHA FLORES, Denys [BR/BR]; Apartamento 162, Rua Augusto de Toledo, 45, 01542-020-São Paulo, SP (BR). DOS SANTOS, Carlos, Henrique, Gaspar [BR/BR]; Apartamento 172, Rua Contos Gauchescos, 55, 04369-000-São Paulo, SP (BR).			
(74) Agents: ARNAUD, Antonio, M., P. et al.; 7th floor, Rua José Bonifácio, 93, 01003-901-São Paulo, SP (BR).			

(54) Title: A BIMETALLIC STRIP FOR A SLIDING BEARING AND PROCESS FOR PRODUCING SAID BIMETALLIC STRIP**(57) Abstract**

A bimetallic strip for a sliding bearing and process for producing said bimetallic strip, the latter being of the type comprising a sliding strip (1), which is made of aluminium alloy and which is adhered to a supporting strip (2), which is usually made of steel and which is optionally coated with a nickel coating interlayer (3). The process comprises the following steps) a- casting by the quick solidification process (roll cast) an alloy comprising from 3 to 30 % of tin, from 1 to 6 % of silicon and the remaining being of aluminium and accidental impurities, by pouring the cast alloy between two cold rolling cylinders, in order to obtain at least 95 % of the silicon particles smaller than 3.5 microns and an aluminium grain average size of about 6 microns; b) annealing the aluminium alloy sliding strip (1) in a heater at a temperature range from 200 to 500 °C; c) setting, optionally, the thickness of the sliding strip (1), through cold rolling passes, followed by respective annealings, as defined in the previous step; d) hot rolling (cladding) together the sliding strip (1) and the steel supporting strip (2), in order to form the bimetallic strip; e) heat treating the bimetallic strip between 200 and 380 °C, so as to obtain a metallurgical bonding between the strips; f) subjecting the metallic strip to a solubilizing process of the intermetallic compounds of the aluminum alloy, by sudden heating at 380-500 °C, followed by sudden cooling; and g) subjecting the bimetallic strip to an artificial precipitation treatment in a heater, at a temperature from 150 to 250 °C.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

A BIMETALLIC STRIP FOR A SLIDING BEARING AND PROCESS
FOR PRODUCING SAID BIMETALLIC STRIP

Field of the Invention

5 The present invention refers to a bimetallic strip, which is used in the formation of sliding bearings for internal combustion engines and which comprises a strip, which is made of an anti-friction or sliding material in aluminum base alloy usually containing
10 silicon, tin and copper and which is adhered to a steel supporting strip. The present invention is also related to a process for producing said bimetallic strip.

Background of the Invention

The internal combustion engines have been designed to
15 work with increasingly higher speeds and loads, thereby requiring sliding bearings, which are able to support these increasingly severer operational conditions, through improved fatigue resistance and anti-sticking characteristics, and which can operate with forged
20 steel or cast iron crankshafts, without the need to protect the bimetallic strip with a lead/tin electrodeposited overlayer.

It is known that the high fatigue resistance characteristics of these aluminum base alloys result
25 from a finer and more uniform distribution of the silicon particles in the aluminum phase.

Nevertheless, the known alloys of these type, such as that described in U.S. Patent 4,696,867, still present a silicon particle distribution which, in spite of a
30 possible addition of small amounts of strontium or sodium to said alloys, does not reach a desirable refining to obtain a load capacity compatible with the operational requirements of the modern internal combustion engines.

35 The grain size of the known alloys of this type is from

about 20 to 50 μm , avoiding the achievement of substantial increases of fatigue resistance in the produced bimetallic strips (see fig.3 in the drawings). Besides the inconveniences cited above, it should be
5 observed that the tin percentages of about 8% or more in the alloy composition do not allow said alloy, after its usual casting, to be hot rolled to the desired thickness for the sliding strip, because hot rolling these alloys presents the risk of the tin being
10 squeezed out.

Another deficient aspect of the known solutions refers to the lack of treatment steps of the bimetallic strip, so as to obtain, in the sliding strip, a compound that is capable of hardening the aluminum alloy, increasing
15 even more its fatigue resistance through a more accentuated silicon refining.

These prior art aluminum alloys are cast into billets with a shape which is very different from that to be attained by the sliding strip, thus making difficult
20 and costly the manufacturing process of the bimetallic strip and the achievement of the minimum silicon refining in the alloy structure.

Disclosure of the Invention

It is an objective of the present invention to provide
25 a bimetallic strip for sliding bearings, which comprises an aluminum base alloy containing silicon and tin and which presents a structure with a high degree of silicon-tin refining, improved properties of fatigue resistance, anti-sticking and adherence to a supporting
30 strip, without requiring the presence of strontium or sodium in the composition of the aluminum alloy and without leading to risks of the tin being squeezed out during the hot rolling steps of the sliding strip material.

35 Another objective of the invention is to provide a

process which allows to obtain the above cited bimetallic strip in a economically feasible way.

Brief Description of the Drawings

The invention will be described below, with reference
5 to the attached drawings, in which:

Fig. 1 is a sectional view of a length portion of a bimetallic strip of the type used in the present invention;

Fig. 2 is a block diagram, illustrating the steps of
10 the manufacturing process of the bimetallic strip shown in fig. 1;

Fig. 3 is a metallographic representation of the sliding strip structure of a bimetallic strip produced in accordance with the prior art;

15 Fig. 4 is a metallographic representation similar to that of fig. 3, but relative to the sliding strip of the bimetallic strip the present invention; and

Fig. 5 is a block diagram, illustrating the steps in the manufacturing process of the bimetallic strip
20 including an aluminum interlayer.

Best Mode for Carrying out the Invention

According to a first aspect of the invention with respect to figure 1, the bimetallic strip comprises a sliding strip 1, which is made of an aluminum base
25 alloy, and which is adhered to a supporting strip 2 usually in steel, through a nickel coating layer 3 applied onto the supporting strip 2.

The aluminum alloy comprises from 3 to 30% of tin; from 1 to 6% of silicon and the remaining being of aluminum
30 and accidental impurities. It has the shape of a strip, which is cast by quick solidification, with a thickness slightly superior to that of the sliding strip 1 to be formed onto the supporting strip 2, said sliding strip 1 being structurally solubilized and artificially
35 precipitated, in order to present an aluminum grain

size of about 6 μm . This alloy has the silicon hard particles finely dispersed in the aluminum matrix, as illustrated in figure 4, at least 95% of said particles being smaller than 3.5 microns.

- 5 In a preferred composition, the alloy may further include at least one of the hardening elements: Ni, Mn, Cr, Cu and Ti, in the range from 0.05 to 5%, with the aim of increasing the mechanical properties and the wear, fatigue and sticking resistances.
- 10 In case the alloy is provided with one or more of the above additives, at least 95% of the silicon hard particles will be smaller than 3.5 microns and 5%, at maximum, will vary from 3.5 to 5 microns.

According to a second aspect of the invention related
15 to figure 2, the process for producing the above cited composite material comprises the following steps:

- a- casting by the quick solidification process (roll cast) an alloy comprising from 3 to 30% of tin, from 1 to 6% of silicon, optionally from 0.05 to 5% of at
20 least one of the hardening additives mentioned above and the remaining being of aluminum and accidental impurities, by pouring the cast alloy between two cold rolling cylinders.
- b- annealing the aluminum alloy sliding strip 1 in a
25 heater at a temperature range from 200 to 500°C;
- c- setting, optionally, the thickness of the sliding strip 1, through cold rolling passes, followed by respective annealings, as defined in the previous step;
- d- hot rolling (cladding) together the sliding strip 1
30 and the steel supporting strip 2 coated with a nickel film 3, in order to form the bimetallic strip;
- e- heat treating the bimetallic strip between 200 and 380°C, so as to obtain a metallurgical bonding between the strips;
- 35 f- subjecting the bimetallic strip to a solubilizing

process of the intermetallic compounds of the aluminum alloy, by sudden heating at 380-500°C, followed by sudden cooling; and

g- subjecting the bimetallic strip to an artificial
5 precipitation treatment in a heater, at a temperature from 150 to 250°C.

The casting step by quick solidification (roll cast) allows the production of a sliding strip 1, which has been quickly solidified by the metallic bath and which
10 has a reduced thickness, in millimeters, that is already very close to the thickness to be maintained in the final product. Said sliding strip further presents a quite refined structure, mainly in terms of silicon and tin dispersion in the aluminum phase. The refining of
15 the hard particles, i.e., silicon and silicon compounds, reaches a level in which 100% of the particles are smaller than 3.5 microns. Optionally, the alloy may contain the above cited hardening additive elements and have the dimension of the hard particles
20 controlled, in order to obtain 95% of the particles smaller than 3.5 microns and the remaining 5% varying from 3.5 to 5 microns. Thus, it is possible to initiate the manufacture of a product which is more resistant to fatigue and sticking than those known products, by
25 using an aluminum alloy containing silicon, tin and copper, but without strontium or sodium, which the prior art considers as adequate for better refining the structure of this kind of alloy.

Another unexpected effect in the alloy structure, in
30 function of the casting process, is that the sliding strip 1 may be hot rolled at high temperatures, without the tin being squeezed out, even when said tin is found in percentages higher than 8%.

The solubilizing step may be achieved, by said
35 bimetallic strip being subjected to a liquid bath, such

as a lead bath, said bimetallic strip being then subjected to sudden cooling through jets of water, for example. This treatment promotes a substantial increase in the load capacity of the bimetallic strip to be produced.

The artificial precipitation is made in heaters, whereto the coils are fed in a discontinuous way.

The bimetallic strip may then be shaped for producing the sliding bearing.

10 Another unexpected aspect of the invention resides in the fact that the average size of the aluminum grain, corresponding to 50 microns in the prior art, is reduced to about 6 microns in the new sliding strip 1, which is obtained by roll cast or hot cladding.

15 Figure 5 illustrates a variant of the process, in which there is provided a nickel or aluminum interlayer, onto which a sliding strip is formed and rolled, the latter being obtained by quick solidification.

CLAIMS

1. A bimetallic strip for a sliding bearing, comprising a sliding strip (1), which is made of aluminum alloy
5 and which is adhered to a supporting strip (2), which is usually made of steel and which is optionally coated with a nickel coating interlayer (3), characterized in that the weight of the sliding strip (1) consists from 3 to 30% of tin; from 1 to 6% of silicon and the
10 remaining being of aluminum and accidental impurities, said sliding strip having at least 95% of the silicon hard particles smaller than 3.5 microns and an aluminum grain average size of about 6 microns.
2. A bimetallic strip, as in claim 1, characterized in
15 that the aluminum alloy of the sliding strip (1) further includes, by weight, from 0.05 to 5% of at least one of the following hardening elements: Ni, Mn, Cr, Cu and Ti, said alloy presenting at least 95% of the silicon hard particles and hardening additive
20 elements smaller than 3.5 microns and, at maximum, 5% varying from 3.5 to 5 microns.
3. A bimetallic strip, as in claim 1 or 2, characterized in that it further comprises an interlayer, in one of the elements defined as nickel
25 and aluminum, disposed between the sliding strip (1) and the supporting strip (2).
4. Process for producing a bimetallic strip for a sliding bearing, said bimetallic strip comprising an aluminum alloy sliding strip (1), adhered to a
30 supporting strip (2), usually in steel and optionally coated with a nickel coating interlayer (3), characterized in that it comprises the following steps:
a- casting by the quick solidification process (roll cast) an alloy comprising from 3 to 30% of tin, from 1
35 to 6% of silicon and the remaining being of aluminum

and accidental impurities, by pouring the cast alloy between two cold rolling cylinders, in order to obtain at least 95% of the silicon particles smaller than 3.5 microns and an aluminum grain average size of about 6
5 microns;

b- annealing the aluminum alloy sliding strip 1 in a heater at a temperature range from 200 to 500°C;

c- setting, optionally, the thickness of the sliding strip 1, through cold rolling passes, followed by
10 respective annealings, as defined in the previous step;

d- hot rolling (cladding) the sliding strip 1 and the steel supporting strip 2 together, in order to form the bimetallic strip;

e- heat treating the bimetallic strip between 200 and
15 380°C, so as to obtain a metallurgical bonding between both strips;

f- subjecting the bimetallic strip to a solubilizing process of the intermetallic compounds of the aluminum alloy, by sudden heating at 380-500°C, followed by
20 sudden cooling; and

g- subjecting the bimetallic strip to an artificial precipitation treatment in a heater, at a temperature from 150 to 250°C.

5. Process, as in claim 4, characterized in that the
25 sliding strip (1) which is being cast in step a comprises from 0.05 to 5% of at least one additive hardening element selected from the group consisting of Ni, Mn, Cr, Cu and Ti.

6. Process, as in claim 5, characterized in that the
30 sliding strip (1) presents at least 95% of the silicon particles and additive hardening elements smaller than 3.5 microns and, at maximum 5% varying from 3.5 to 5 microns.

7. Process, as in any of claims 4, 5, or 6,
35 characterized in that the sliding strip (1) is cast by

quick solidification together with its rolling onto an aluminum or nickel strip, which defines an interlayer between the sliding strip (1) and the supporting strip (2).

1/3

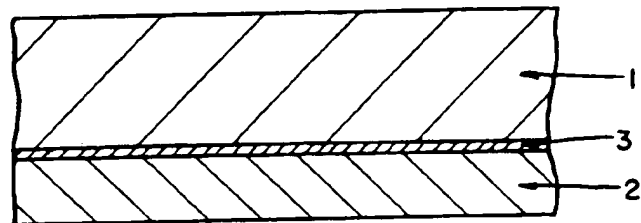


FIG.1

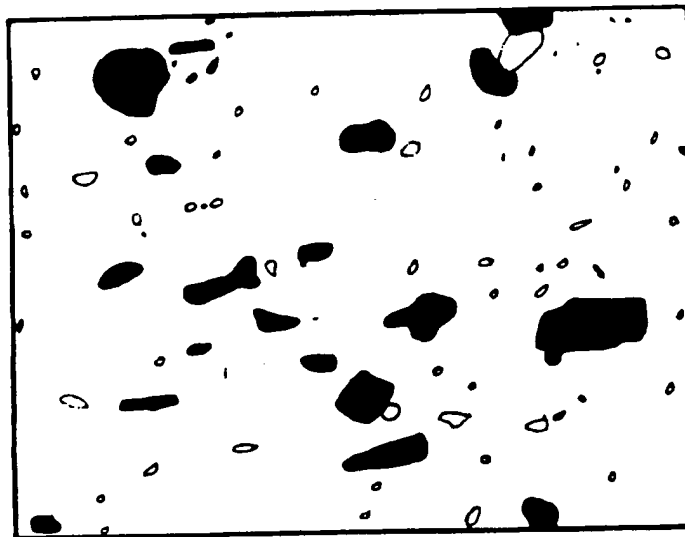


FIG.3
PRIOR
ART

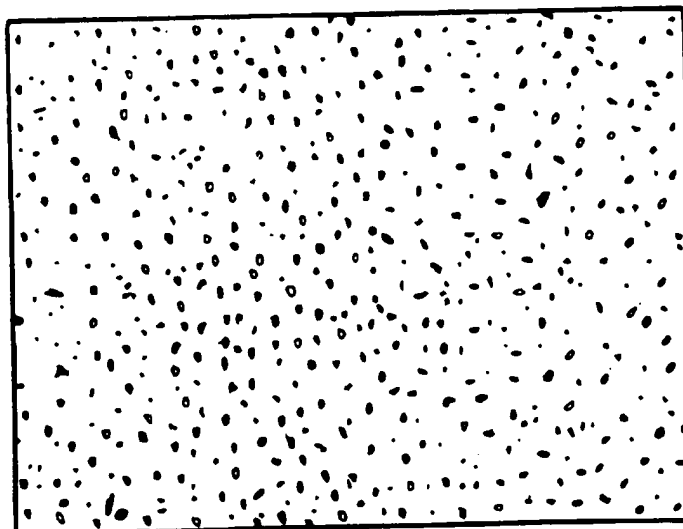


FIG.4
INVENTION

2/3

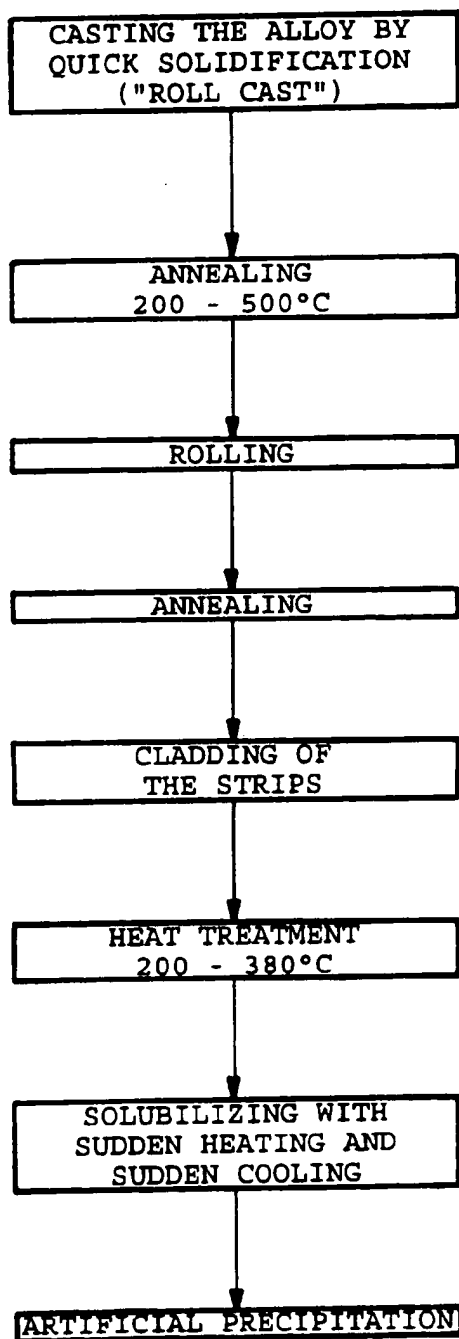


FIG.2

3/3

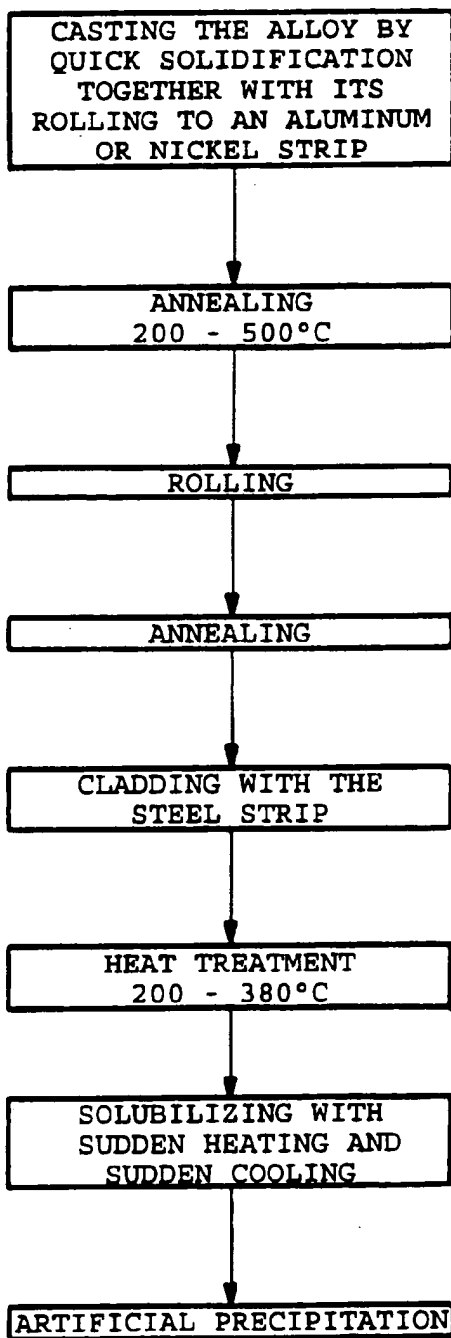


FIG.5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/BR 95/00034

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B32B15/01 C22C21/00 F16C33/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B32B C22C F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE,A,37 30 862 (GLYCO-METALL-WERKE DAELEN & LOOS) 23 March 1989 see the whole document ---	1,4
Y	FR,A,2 189 527 (ALCAN RESEARCH AND DEVELOPMENT LTD.) 25 January 1974 *Claims 1-8* ---	1,4
Y	FR,A,2 124 748 (GLACIER METAL COMPANY LTD.) 22 September 1972 *Claims 1-26* ---	1,4
A	US,A,3 268 369 (D.E.HAUGEN) 23 August 1966 see the whole document ---	1,4
A	US,A,4 471 029 (FUKUOKA ET AL.) 11 September 1984 *Claims 1-10* ---	1,2
-/--		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

11 October 1995

Date of mailing of the international search report

24. 10. 95

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

Lippens, M

INTERNATIONAL SEARCH REPORT

International Application No

PCT/BR 95/00034

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 471 033 (FUKUOKA ET AL.) 11 September 1984 *Claims 1-10*	1,2
A	DE,A,36 31 029 (NDC CO.LTD.) 26 March 1987 see the whole document	1-3

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/BR 95/00034

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A-3730862	23-03-89	WO-A- 8902365	23-03-89
FR-A-2189527	25-01-74	CA-A- 1024833	24-01-78
		DE-A- 2331498	17-01-74
		US-A- 3833983	10-09-74
FR-A-2124748	22-09-72	NONE	
US-A-3268369	23-08-66	GB-A- 931584	
US-A-4471029	11-09-84	NONE	
US-A-4471033	11-09-84	NONE	
DE-A-3631029	26-03-87	JP-B- 6017529	09-03-94
		JP-A- 62218538	25-09-87
		JP-C- 1616823	30-08-91
		JP-B- 2035020	08-08-90
		JP-A- 62063635	20-03-87
		AU-B- 605110	10-01-91
		AU-B- 6260286	19-03-87
		GB-A, B 2182348	13-05-87
		US-A- 4789607	06-12-88